WATER RESOURCES BRANCH

DIRECTION DES RESSOURCES EN EAU

ISSUE PAPERS

T. Winkler and P. Pilon (eds.)

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WATER RESOURCES BRANCH

ISSUE PAPERS

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WATER RESOURCES BRANCH ISSUE PAPERS
INTRODUCTION

Origins

The idea for Water Resources Branch (WRB) issue paper analysis originated at a Water Resources Branch Managers meeting held in 1989 (Banff, 7-9 November) as part of the WRB discussion for the development of a strategic plan. Credit is due to the Chief, Water Survey of Canada (WSC) Division for pursuing this initiative vigorously to produce WSC Issue Papers during 1989 and 1990. This represented a significant effort by WSC Managers across Canada. The perspective of the Hydrology Division of WRB, based on input by the Managers and staff from that Division, was then incorporated to produce this version.

Objectives

Water management is increasingly being oriented towards the resolution of environmental issues and WRB realizes that it must make more apparent the links between its work and the issues. As such, there are two main purposes of the WRB Issue Papers. First, the aim is to provide WRB staff with appreciation of these issues, what the federal government is doing, and what the Branch is and could be doing towards the resolution of the issues. Second, the papers provide information relevant to planning, the WRB Priority Papers, and the WRB strategic planning initiative known as Directions for the 90s. In addition, parts of the Papers could be used as a basis for information for the Directorate, Department, potential clients, and the public. Hence, the Issue Papers could further serve a communications role external to the Branch. Such attention to environmental issues will help the Branch to remain a relevant, vibrant organization meeting the water management needs of Canada.

Content

Each Issue Paper includes: an explanation as to why the issue is important; causes and effects; extent in Canada; international significance to Canada if relevant; federal involvement; links with WRB programs; current WRB activities of relevance to the issue; and potential opportunities for WRB.

Perspective

The Water Resources Branch is one of four branches and two research institutes of the Inland Waters Directorate (IWD), Environment Canada. The others are the Water Quality Branch, Water Planning and Management Branch, Program Analysis and Coordination Branch, National Water Research Institute, and the National Hydrology Research Institute. All contribute towards the mission of IWD to promote wise management and protection of water in Canada and globally as a vital contribution to sustainable development.

As indicated in Directions for the 90s, the Branch plays a vital role by providing the data, information, and expertise necessary for sound water management decision-making, and also by providing advice and analysis on related

hydrologic and environmental issues. Water quantity, sediment, and other data are collected under the Federal Provincial/Territorial Agreements on cost-sharing with the Provinces and Indian and Northern Affairs Canada on behalf of the Territories. Part of the vision of Branch for the 1990s includes a broadening of the range of hydrologic monitoring, information, and assessment service in areas such as groundwater, water quality, and meteorology. At the same time, WRB will ensure that its products, services, and technology are efficient and appropriate to meet present and future water management needs. These Issue Papers should help provide a framework of such needs and a brief, but not necessarily complete, description of how WRB can fulfil its vision.

The table which follows summarizes the contributions of the Water Resources Branch to the various issues.

WATER RESOURCES BRANCH ISSUE PAPERS
SUMMARY TABLE WRB ROLE

ISSUE	SIGNIFICANCE TO WRB	SPECIFIC CONTRIBUTIONS BY WRB
Acid Precipitation	Due to the impacts of acid precipitation on aquatic ecosystems, basic hydrometric and sediment data are required to examine the extent and consequences of acid precipitation. Since sediment stores toxic substances, which can be released into the environment as a result of acid precipitation, the quantity of sediment is a factor in understanding the processes and impacts of acid precipitation.	Water Survey of Canada (WSC) field staff collect water quantity and quality data at sites in Quebec, Ontario, and the Atlantic provinces in support of activities on the long-range transport of airborne pollution (LRTAP). Meteorological data such as precipitation and wind speed and direction also are collected by staff at numerous hydrometric stations across Canada. WSC monitors runoff from a lake in Nova Scotia, in cooperation with Fisheries and Oceans Canada, which is conducting a winter liming experimental project.
Aquatic Habitat/ Ecology	Since water and sediment play significant roles in regulating aquatic productivity and the transport of nutrients and contaminants to and within aquatic ecosystems, WRB products play a role in the management of aquatic habitat.	About 13 percent, or an estimated 354 hydrometric stations are used for aquatic habitat/ecological purposes. Data for about 50 to 100 gauging stations are supplied regularly to Ducks Unlimited, a major cooperator in the North American Waterfowl Management Plan (NAWMP), for studies and water management purposes. In the Northwest Territories data are supplied to Fisheries and Oceans Canada for the Northern Oil and Gas Program (NOGAP), which includes fisheries concerns of the Mackenzie Delta.
Climate Change	WRB can provide a long-term network of hydrometric and sediment stations with the capability of providing data necessary to quantify the areal and temporal effects of climate change on streamflow regimes, sediment transport, and river morphology. Unregulated or natural sites, with long data records, would be most useful. Historical data stored in the national database HYDAT could be used. It would be necessary, however, to quantify human activity that could influence the flow and sediment regimes--the ability to depict basin changes over long periods may be difficult and may even be impossible. Water quantity data currently are used for modelling scenarios of impacts and response strategies.	WRB HQ is committed to work with WRB Ontario Region on a project to assess hydrometric networks and data to determine their adequacy for detection of effects of climate change. Work from the Atlantic and Pacific and Yukon Regions can be incorporated. WRB has data from 4389 active and discontinued unregulated sites, and 2175 active stations. There are 17 unregulated stations with 60 years or more data, 88 with 50 or more years, and 174 with 40 or more years. However, the degree of human intervention has not been assessed for the basins. Hydrometric gauge sites are being utilized in cooperation with the Atmospheric Environment Service (AES) and using our data collection platforms (DCPs) to monitor weather parameters at a number of remote (Northern) areas to fill in gaps of weather and hydrometeorological data. Hydrometric data are used in climate change studies. An example is the study by AES and the National Hydrology Research Centre on Possible Impacts of Climatic Warming Scenarios on Water Resources in the Saskatchewan River Subbasin (1989).

ISSUE	SIGNIFICANCE TO WRB	SPECIFIC CONTRIBUTIONS BY WRB
Drinking Water	Hydrometric data provide information on available water supply, and as such are applicable to the design of drinking water facilities. After use and subsequent treatment, water quantity and sediment data are collected to monitor discharge from sewage treatment plants. Streamflow and sediment data are used in regulatory measures with regard to amounts of effluent which can be released.	About seven percent, or an estimated 190 hydrometric stations of WRB are used for water supply and sanitation purposes. WRB collects surface water samples of inflow and outflow for sewage treatment lagoons in support of provincial Ministry of Environment programs (ie. Ontario). Data from approximately 50 sites in Alberta, for example, are directly used for drinking water study purposes. A much larger portion of the network (300 sites) is utilized in water availability studies. In addition, there are occasions when WRB staff in Alberta are called upon to do direct measurements of effluents, inflows, and internal distributions within treatment plants.
Energy	Since information on the availability and reliability of water is necessary for the design, construction, and operation of energy-producing facilities, particularly hydroelectric power, WRB plays a role in energy production. Hydroelectric power production itself depends on the flow and head available in a river reach. Water quantity data are essential for the operation of the facilities; knowledge of the pattern of water availability throughout the year is important for optimal planning of energy production. A conservative estimate of the value of hydrometric data for design of hydroelectric projects is 5 percent of total construction expenditure, or about $64.3 million per year (data from 1977). One of the most extensive uses of sediment data is for reservoir studies, for which suspended and bedload sediment data are needed for reservoir design.	About 12 percent, or an estimated 330 hydrometric stations are used for energy purposes. In Alberta, for example, 30 real-time gauging sites are directly used by reservoir operators in the day-to-day decision-making process. These are not only used by operators, but, because of the interprovincial flow aspects of the major streams arising in Alberta, also by Saskatchewan and Manitoba operators. WRB analytical software such as consolidated frequency analysis (CFA) is used by designers of spillways for hydroelectric facilities. Regionalization techniques are developed and are made available to the hydrologic community to translate site-specific data into information for a region or area.

ISSUE	SIGNIFICANCE TO WRB	SPECIFIC CONTRIBUTIONS BY WRB
Floods/ Droughts	Since floods and droughts are hydrologic extremes, WRB activities are fundamental for their forecasting, analyses of severity, and frequency. Real-time data are particularly useful for the first two activities, while historical data such as those stored in the national data base HYDAT are fundamental for all three activities. A rough estimate of the value of hydrometric data for the design and construction for flood control is $2.9 million annually (1977). WRB data contribute to drought forecasting, for apportionment of water during drought conditions, as well as drought planning, impact studies, and ecosystem conservation. Sediment plays a role both in flood and drought conditions (ie: erosion, water supply intakes).	About 54 percent, or an estimated 1445 hydrometric stations are used for flow forecasting and floodplain management purposes. About 800 stations or one quarter of the total hydrometric network in Canada have some type of real-time data capability. WRB has a role under the Green Plan to establish water level equipment above major urban centres for flood forecasting purposes. For drought, 1100 of the 2700 WRB hydrometric and sediment stations across Canada are located in the three Prairie provinces. Each year, outlooks for spring runoff are prepared by the three Prairie provinces, with streamflow data provided to the River Forecast Centre of Alberta Environment, the Hydrology Service of the Saskatchewan Water Corporation, and the Manitoba River Forecast Centre of Manitoba Natural Resources. The Prairie Farm Rehabilitation Administration (PFRA) prepares a quarterly report on water supply conditions and utilizes data from 30 selected streamgauging stations to ascertain the significance of flows and compare them to long-term conditions. During severe drought conditions reports are prepared more frequently. Hydrometric data are used by the Prairie Provinces Water Board, among the three Prairie provinces, to ensure that 50 percent of natural flows pass to downstream jurisdictions. Such apportionment becomes more important during times of drought, requiring that timely and accurate streamflow data be available. In Alberta, for example, about 80 stations are used in this monitoring. Interpretive reports on the occurrence of large flood events are prepared and distributed to the hydrologic community.
Groundwater	Surface water is linked to groundwater movement and availability in a region. Information from stream gauging stations (recessional flows) can be used in assessing groundwater supplies and quality.	Under the federal-provincial agreements on water quantity surveys, staff in New Brunswick and Prince Edward Island operate recording instruments and process data for a number of groundwater wells. Otherwise, the current WRB role in groundwater management is minimal.

ISSUE	SIGNIFICANCE TO WRB	SPECIFIC CONTRIBUTIONS BY WRB
Interjurisdictional Issues	Interjurisdictional agreements are fundamental to the work carried out by WRB. WRB is responsible for and participates in numerous agreements. The data collected are accepted by all parties involved in interjurisdictional problems.	WRB is the principal agency responsible for the federal-provincial/territorial Water Quantity Survey Agreements and operates about 2700 of 3300 hydrometric stations and 200 sediment stations in Canada under the Agreements. The objectives of the Agreements are to maintain a viable and efficient national hydrometric network and to give recognition to joint federal and provincial responsibilities in this activity. Mutual benefits include efficient and effective operation of networks, and standardization of data on a national basis. WSC operates about 95 "international gauging stations" for use under the Boundary Waters Treaty, Great Lakes Water Quality Agreement, etc., to help fulfil Canada-US obligations. Streamflow, water level, and related data are used by international and federal-provincial water boards. One example is the Lake of the Woods Control Board, established in 1919 between Canada, Ontario, Manitoba, and the USA. Its objective is to control and regulate certain major waterways in the Winnipeg River drainage basin to achieve water flow and level conditions that are reasonably acceptable to the various interests. Another example is the Prairie Provinces Water Board, between Canada, Alberta, Manitoba, and Saskatchewan, for the equitable apportionment of eastward flowing interprovincial prairie waters. The agreement ensures that one-half the natural eastward flow of waters arising in or flowing through Alberta is reserved for Saskatchewan, and that one-half the eastward flow arising in or flowing through Saskatchewan is reserved for Manitoba. In Alberta, for example, WSC operates about 80 stations for this purpose. For the Flood Damage Reduction Program, WRB data, a frequency analysis package, and regionalization approaches are used to delineate the flood plain and to determine the 100-year floods, ie: the areas at risk and the magnitude of the risk. WRB has a role under the Green Plan to establish water level equipment above major urban centres for flood forecasting purposes. Under the Green Plan, WRB is working with Indian Affairs and Northern Development Canada, the territories, etc., to expand and modernize hydrometric stations in all major northern water basins.

ISSUE	SIGNIFICANCE TO WRB	SPECIFIC CONTRIBUTIONS BY WRB
Science and Technology	WRB uses science and technology in its programs and further develops them.	WRB develops and tests hydrometric equipment. Examples are flow meters for measurement of flow under ice, perfection of a moving boat method for the measurement of flow, and provisions for other environmental parameters on our data loggers. WRB adapts sediment equipment developed by the United States Geological Survey (USGS) for its own uses and conditions, which subsequently may be incorporated into USGS designs. Computer software known as COMPUMOD is being developed to provide technical staff with data handling, processing, and analysis capabilities. COMPUMOD will provide capabilities not yet available on the software market. The Branch provides expertise to scientific studies, such as for the St. Lawrence River at the Centre St. Laurent. WRB formulates national standards for hydrometric and sediment data collection, data analysis and control, and measurements of flow under ice. Artificial intelligence/expert systems are being investigated for potential application in the collection of data and information.
Soil Erosion/ Salinity	Hydrometric and sediment data are useful to determine the rate of erosion, timing, and contaminants carried from agricultural basins by the sediment to water bodies.	WRB participates in special programs with other federal and provincial agencies to investigate the effects of varying soil tillage techniques on rural runoff quality. Sediment analysis reports are prepared for long-term sediment monitoring sites which provide collected data in readily usable formats to scientists and others involved in erosion studies. One example is a source study contracted to Alberta Research Council for the Oldman River basin. Hydrometric data are used in erosion studies. An example is a study done by the Western and Northern Region on off-farm sediment impacts in the Saskatchewan River Basin.
Toxic Substances	Since the management of toxins must consider all relevant components of the environment (water, sediment, air, biota) to be effective, WRB has a role to play in initiatives to eliminate toxins. As they can be dissolved or attached to sediment particles, streamflow and sediment data are valuable to studies on toxins, including sources of the chemicals, extent of contamination, impacts, assessment of remedial action.	WRB provides equipment, expertise, and data which are instrumental in the research of the Centre Saint-Laurent. Streamflow data are used to calculate mass loadings of toxic substances entering the Great Lakes, the loadings information being required under the Great Lakes Water Quality Agreement.

ISSUE	SIGNIFICANCE TO WRB	SPECIFIC CONTRIBUTIONS BY WRB
Urban Hydrology	Not only are WRB data important to understand the hydrology of urban areas, but they are used for: the design and construction of catchment retention basins and bridges; the assessment of flood plains and the development of flood damage reduction plans; for flow forecasting; for determining erosion rates; and flood control assessment of point and non-point sources of pollution, as examples. Private industry, municipalities, and provincial agencies use the data.	There are hydrometric and sediment monitoring stations located across Canada in urban centres and in rural areas above urban centres. WRB has a role under the Green Plan to establish water level equipment above major urban centres for flood forecasting purposes. These will be placed in conjunction with a weather network.
Water Supply	Since an inventory of water quantity and assessment of the reliability of this available water are necessary for water supply, WRB has a role to play in this field. Long-term stations are important for reliable estimates, while real-time data are useful during drought conditions. Sediment data are required in the design of filters and intakes of water supply systems.	About 60 percent of WRB's 2700 hydrometric stations have as one of their uses the role of inventory of available water supply. About seven percent, or an estimated 190 hydrometric stations are used directly for water supply and sanitation purposes. Network planning and evaluation activities ensure that networks are as efficient and complete as possible given the available funds. Regional transfer methodologies and analytical approaches to determine the reliability of water supply are used by WRB. These methodologies translate site-specific data into information for a region or area.
Wetlands	The water quantity and sediment monitoring of WRB are relevant to the planning and management of wetlands sites. For wetlands projects, an integral part of establishing project feasibility is the determination of yield from the drainage basin, which requires flow statistics. In terms of project design, water control structures such as dams, dykes, weirs, and culverts may be used to manage the wetlands, and hence, hydrometric data are needed to determine flood maximums. Sediment data help indicate the overall health of the ecosystem, help identify sources of contaminants, and processes involved in pollutant trapping.	About 13 percent, or an estimated 354 hydrometric stations are used for fisheries management. Data for about 50 to 100 gauging station sites are supplied regularly to Ducks Unlimited, a major cooperator in the North American Waterfowl Management Plan (NAWMP), for studies and water management purposes. For Alberta, an estimate is that 50 to 80 hydrometric and one or two sediment stations are used for wetlands. WRB data are used to study the potential impacts of climate change on wetland hydrology, an example being the study done by the National Hydrology Research Institute of IWD, McMaster University, and Ducks Unlimited.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: ACID PRECIPITATION

Significance

Acid precipitation in the form of rain and snow can contaminate land and water, ultimately affecting animal and human populations. In fact, the effects of acid precipitation can be devastating--it has the potential to kill all forms of life.

On land, effects include those on humans, animals, and material goods like buildings, forests, and agriculture. Impacts on humans can be felt through contamination of edible fish, drinking water supplies, and respiratory ailments. A US research team reported that acid haze over eastern Canada is blocking sunlight at the wavelength that people need to manufacture vitamin D and is likely driving up rates for two serious forms of cancer. The deterioration of buildings and other materials is accelerated. Forest and agricultural productivity can decrease because of nutrient deficiencies caused by leaching of chemicals. Furthermore, even if all pollution contributing to acid precipitation were eliminated, it is estimated that it would take 25 years or more to see signs of recovery in forests. Annual health costs in Ontario from acid precipitation are estimated to be $80 million. Total damage in eastern Canada is estimated to be about $1 billion annually.

In water bodies, the lowering of pH can lead to: release of toxic forms of metals like aluminum, copper, and mercury that might otherwise not be bioavailable, including those from sediment; decline in microbiological activity; disruption of the food cycle of fish and other species; decline in the ecological diversity of the system; and reproductive failure of some fish species. In extreme circumstances, because species cannot survive, lakes are known to be devoid of fish.

Sources of the sulphur and nitrogen oxides of acid rain include metal and ore smelting, the combustion of coal and oil, including automobile exhaust, chemical manufacturing, oil and gas refining, and agricultural pesticides.

While over 80 percent of Canadians live in areas with high levels of acid precipitation-related pollution, certain regions of Canada are affected more than others. The Canadian Shield, particularly central and eastern Canada, are affected because of wind patterns, and type of bed rock. The overburden and sediments lack the buffering capacity to keep acidity in check. An estimated 14,000 lakes from Manitoba to Newfoundland are dead and 150,000 are at risk.

Canada is affected also by pollutants outside its boundary. More than half the acid deposition in eastern Canada originates in the United States. Fortunately, the US revised its Clean Air Act in 1990 such that by the year 2000 sulphur dioxide emissions from American power plants will be cut by almost 50 percent from the levels of 1980.

Federal Involvement

While the control of pollutant emissions is considered to be the responsibility of provincial governments, because of the extent of the country affected and the importance of the issue, Fisheries and Oceans Canada and Environment Canada also do research on acid precipitation. An Experimental Lakes Area in northwest Ontario has been operational for years, as has the Acid Rain Turkey Lakes Watershed.

A National Clean Air Act was adopted in 1971 by the federal government, which sets out non-binding national air quality objectives. The Act is not meant to regulate individual sources, but instead under provincial legislation such as Ontario's Environmental Protection Act, emissions from specific sources can be regulated. Under an international agreement, however, the federal government would have the power under the Clean Air Act to regulate sources contravening such an agreement.

In 1985, the federal government announced a comprehensive program, the Canadian Acid Rain Control Program, to cut Canada's acid rain emissions. Under cooperative agreements with the seven eastern-most provinces and industry, measures have been implemented to reduce sulphur dioxide emissions by 1994 to levels that will be 50 percent of 1980 emission levels. Sulphur dioxide emissions from sources in eastern Canada have already been reduced by 40 percent and as of 1990 the 1994 targets are envisaged to be achieved.

As stated in the Green Plan (1990), Canada's goal is to cap acid rain-related emissions in eastern Canada beyond 1994 through extended federal-provincial agreements. In addition, it will expand the control program to establish a national emission cap for the year 2000. Canada will seek to conclude a Transboundary Air Quality Agreement with the United States as quickly as possible. More specific to water resources, the federal government will continue its acid precipitation research and monitoring efforts to verify their adequacy, including determining the rate and extent of lake and river recovery from acid rain damage.

The Inland Waters Directorate has an IWD Strategy for Addressing Atmospheric Issues (1991). Commencing in 1991-1992 the goals for the Directorate as regards to acidification will be: to continue to detect and monitor acidification and its effects on aquatic ecosystems and related human activities; to determine scientifically sound loading values for acidification of aquatic ecosystems on regional and watershed bases; and to provide sound scientific data for periodic national assessments of aquatic ecosystem responses to emission controls and for Canada/US and other multinational negotiations on emissions.

The Green Plan states that all evidence indicates that Canadian and American acid rain control programs will solve Canada's acid precipitation problem and that what remains to be done is to make the solution permanent and to verify that it is adequate.

WRB Role in Acid Precipitation

Due to the impacts of acid precipitation on aquatic ecosystems, basic hydrometric and sediment data are required to examine the extent and consequences of acid precipitation. Acidic loadings to lakes can be seasonal, requiring measurements of water quality and quantity; shocking of water bodies is possible when large amounts of contaminants enter the water system, as in the spring. Since sediment stores toxic substances on its surface, which can be released into the environment as a result of acid precipitation, the quantity of sediment is a factor in understanding the processes and impacts of acid rain. However, while water and sediment data may be used to investigate actual conditions or modelling scenarios, studies to date have tended toward simplified analyses of lake data (calcium, alkalinity, pH), with the end product usually a map of aquatic sensitivity.

Present activities of WRB of relevance to acid precipitation programs and potential activities are outlined below.

Present Activities

- Water Survey of Canada field staff collect water quantity and quality data at sites in Quebec, Ontario, and the Atlantic provinces in support of activities on the long-range transport of airborne pollution (LRTAP). Meteorological data such as precipitation and wind also are collected by WSC staff at numerous hydrometric stations across Canada. For example, five technicians in the Northwest Territories collect large quantities of snow samples for research on LRTAP done by the National Water Research Institute of the Inland Waters Directorate.

- WSC monitors runoff from a lake in Nova Scotia, in cooperation with Fisheries and Oceans Canada, which is conducting a winter liming experimental project.

Potential Activities

- Collect water and sediment samples for quality analyses for acid precipitation studies during routine trips, in cooperation with the Water Quality Branch. This would not be difficult as many nongovernmental organizations routinely perform this function. For long-term trends it is possible that sample collection will not be required annually; sampling on a regular five or 10 year cycle may suffice.

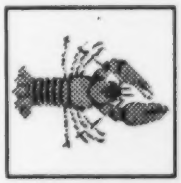
- Provision for water quality sensors on WRB data loggers which collect data automatically.

- Identify acid precipitation index basins suitable for establishing additional hydrometric stations for an interdisciplinary study on acid precipitation trends. Their purpose would be to quantify the effect of regulatory controls on reducing, stabilizing or preventing the

problems of lake acidification. A select number of basins covering different physiographic and climatological zones would have to be researched for quality/quantity data and previous studies. A program/network for integrated environmental monitoring (quality and quantity of streams and precipitation) could be developed leading to analysis and interpretation of data with respect to trends or tendencies that could be linked with industrial atmospheric loadings.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: AQUATIC HABITAT/ECOLOGY

Significance



In 1970, land and water species became extinct at a rate of one per day. In 1990, species became extinct at the rate of one per hour. Agriculture, mining, forestry, transportation, energy development, urban growth, and industry are damaging fish habitats. Almost half the shellfish growing areas in Nova Scotia and 500 square kilometres of prime shellfish harvesting areas in British Columbia are closed due to contamination.

The aquatic habitat contributes a great deal to the Canadian economy. Wetland ecosystems generate between $5 and $10 billion annually in economic benefits to Canadians. (See the Issue Paper on wetlands for more information on this type of aquatic ecosystem.) The commercial fishing industry has revenues of $3.2 billion and employs 130,000 people; commercial fishing represents the only real employment opportunity in some 1500 coastal and remote inland communities. In 1980, sport fishing accounted for $1.76 billion in expenditures and investments in Canada, $300 million of which was contributed by foreign anglers. In addition, fisheries provide recreational opportunities for more than five million Canadians and one million foreign visitors annually.

The aquatic habitat, including waterfowl, is important to the genetic diversity of the planet, and is increasingly threatened by pollution, development, and destruction of the ozone layer, as examples. It is estimated that aquatic systems in some parts of northeastern North America have lost up to 20 percent of their species because of acidification by the long-range transport of air pollutants.

On a general level, the energy in biological systems is derived by photosynthesizing organisms, while in aquatic systems plant productivity is regulated by factors such as light, nutrients, water, and carbon dioxide.

Water and sediment thus play significant roles in regulating ecological productivity in aquatic ecosystems. Food supplies, habitat, and breeding grounds can be adversely affected by the presence of sediment. For example, eggs might be buried by sediments transported from one location to another. Furthermore, fluvial sediments are capable of transporting both nutrients and contaminants to and within an aquatic environment.

At the consultative sessions of the Green Plan on science and technology, Canadians expressed a desire to increase the long-term study of ecosystems, including aquatic and oceanic systems. They wished to better understand man's impact on species diversity, ecosystem stability, and resilience.

Federal Involvement

The federal government embraces an ecosystem approach to the environment, in terms of sustainable development.

One of 25 specific policy statements of the Federal Water Policy (1987) is on fish habitat management. Primary federal responsibility for fisheries lies with Fisheries and Oceans Canada. The Fisheries Act is the federal legislative base for the government's responsibility to conserve and protect fish in Canada's oceans and inland waters. Through this Act the federal government is able to allocate the catch among competing users, licence fishermen and vessels, and protect fish habitat. However, administrative arrangements have been developed with some provinces to foster cooperative conservation and development of Canada's fisheries. British Columbia, the Prairie provinces, Ontario, Quebec and the Yukon have assumed responsibility for managing their freshwater fisheries.

In 1985, the federal government released a national Fish Habitat Management Policy to achieve a net gain of productive fish habitat, under three strategies of conservation, restoration, and development.

The ongoing North American Waterfowl Management Plan (NAWMP) is a $1.5 billion Canada/US agreement (1990), which includes federal, provincial, state governments and nongovernmental organizations, for waterfowl habitat restoration and protection over 15 years. Other commitments with international components are the environmental agreement with Mexico signed in 1990, which includes consideration for migratory species and sites, and designation of Canadian sites for an inventory of internationally significant wetlands of the International Union for Conservation of Nature and Natural Resources (RAMSAR).

Action to protect fish and fish habitat under the Green Plan (1990) includes amendments to the Fisheries Act to increase fines for domestic fisheries and fish habitat violations and to strengthen the enforcement powers of fishery officers, improvements in the level of habitat protection nation-wide through a more consistent application of the Fisheries Act in consultation with provincial governments, expanding scientific assessment, monitoring and research on toxic substances and their effects on fish and fish habitat, and conservation of existing habitat as well as reclamation of lost/degraded habitat. Wetlands also will benefit from the Wildlife Policy for Canada.

Also under the Green Plan, in 1991 the government will adopt the Federal Policy on Wetland Conservation. Elements of the Policy will include a system of secured wetlands of national importance; protection of wetlands on federal lands such as national parks, national wildlife areas and National Capital Commission lands; and wetland conservation as a fundamental goal of all federal land-use decisions.

WRB Role in Aquatic Habitat/Ecology

Sediment monitoring activities of the Branch traditionally have focussed on applications in water resources engineering, such as reservoir sedimentation or engineering design. However, WRB has developed an appreciation of the role and importance of sediments in environmental quality issues, such as fish habitat and

water quality.

Since sediment and water quantity and quality play significant roles in regulating aquatic productivity and the transport of nutrients and contaminants to and within aquatic ecosystems, WRB has a role to play in the management of aquatic habitat. Information on water level, discharge, and sediment can be used to help understand the habitat of various species. Extreme peaks of flow, for example, can significantly alter the beds and banks, which would affect habitat conditions. Streamflow data in conjunction with sediment data such as bed and bank material analysis can be utilized in ecological studies to ascertain the likelihood of damage and changes. In most cases knowledge of the water's quality coupled with water quantity and sediment data provide the necessary information for the successful management of aquatic ecosystems.

Present WRB activities of relevance to aquatic ecosystems and potential activities are outlined below.

Present Activities

- About 13 percent, or an estimated 354 hydrometric stations are used for aquatic habitat/ecological purposes.

- Data for about 50 to 100 gauging station sites are regularly supplied to Ducks Unlimited, a major cooperator in NAWMP, for studies and water management purposes.

- In the Northwest Territories data are supplied to Fisheries and Oceans Canada for the Northern Oil and Gas Program (NOGAP), which includes fisheries concerns of the Mackenzie Delta. WRB also established a station at Tuktoyaktuk for Fisheries and Oceans Canada to obtain flows for fisheries studies.

Potential Activities

- Increase data user base by marketing services to biologists, ecologists, and other specialists involved in studying the aquatic habitat, by continuing client workshops and report series to generate interest in water quantity and sediment-related concerns, and explain the WRB program.

- Prepare accessible/readable reports based on available sediment and hydrometric data for use by scientists in habitat and waterfowl studies. Partnerships with such scientists to use available data could also be considered.

- Participate in cooperative basin habitat/ecology studies, with players such as Ducks Unlimited, the Canadian Wildlife Service, National Water Research Institute, and National Hydrology Research Institute.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: CLIMATE CHANGE

Significance

Global warming could have major ramifications on Canada and the rest of the world--no other single environmental issue could affect Canada more. The potential for climate change now involves not just variation within natural patterns, but transition to new patterns of variation (ie: human-induced). This introduces an additional, complex dimension to the analysis of climate.

Over a long period of time, the economy and environment could be significantly affected. Patterns of agriculture, forestry, energy production, and industry could change, modifying the economic balance of regions, some for the better and some for the worse. As rainfall and temperature patterns shift and as sea levels rise in a biologically short period of time, the environmental balance could be upset; since change would outpace the ability of the species to adapt, many species could become extinct.

Furthermore, because hydrological processes are intimately related to atmospheric processes, climate change would have profound impact on water supply and demand, and the design and management of water resource projects, such as irrigation schemes and hydropower. Many inland wetlands could dry up and large areas could become severely water-deficient requiring large scale remedial measures such as the construction of storage reservoirs and major diversions. Conversely, some areas could become "water-logged" requiring the implementation of extensive drainage works, flood control measures, etc.

Global warming is caused by increased concentrations of greenhouse gases in the atmosphere. In terms of human activity, the gases, their sources, and their relative importance are as follows: carbon dioxide from burning of fossil fuels like coal, oil, gas from industry, energy production, cars, and deforestation account for roughly half of human-induced global warming; chlorofluorocarbons (CFCs) from refrigeration, air conditioning, and insulation contribute some 20 percent; methane from rice fields, cattle, and landfills contributes 15 to 20 percent; and nitrous oxide from chemical fertilizers, slash-and-burn farming, and fossil fuel emissions account for about five percent. Half the carbon dioxide added to the atmosphere throughout human history has been emitted in the past 30 years. Methane emission levels have doubled in the past 100 years. Concentrations of CFCs are doubling every 10 to 20 years. The solution lies in reducing and eliminating the sources of the gases, by developing clean, sustainable methods. Canada ranks second among industrialized nations in terms of carbon dioxide emissions per capita.

Canada would be greatly affected by global warming. Atmospheric warming of 0.5 to 4.5 degrees Centigrade is expected to be greatest at middle and high latitudes (ie. northern areas), making Canada one of the areas likely to experience the greatest effects of any climate-induced change. The Arctic and Prairie regions could increase in temperature. Permafrost areas of Canada's North could melt. Water levels of the oceans surrounding Canada may rise from 0.3 to 1.5 metres

such that many coastal areas could be flooded. The inshore fisheries season could be extended. Increased precipitation in the Arctic and southeastern Canada is projected, with no change or even a reduction in most of the rest of the country, including the Prairies, making them even more susceptible to drought. Soil degradation and erosion of prairie land may increase due to moisture loss. The Great Lakes winter ice may disappear. Southern Ontario snow seasons could disappear. The forest region could shift northward, with deciduous trees growing as far north as James Bay.

Federal Involvement

The Canadian Climate Program was established in 1978 to study climate change and to integrate the efforts of various federal and provincial agencies, universities, and the private sector in the field of climatology. The Atmospheric Environment Service (AES) of Environment Canada is the lead federal agency in the study of climate change. In terms of water, programs of the federal government aim to improve the availability and interpretation of climate data and services, make effective use of climatological information in water resource planning and management, conduct further research on the relationship between climate and water resources, and conduct research on the impact of climate change and variability on water resources. Extensive modelling has been done, to examine possible impact on agriculture, navigation, power generation, ecosystems, water resources, forestry, northern resources, etc.

As stated in the Green Plan (1990), Canada's goal with respect to global warming is to stabilize national emissions of carbon dioxide and other greenhouse gases at 1990 levels by the year 2000. Under a National Action Strategy on Global Warming, three strategies are being pursued: limiting net emissions; anticipating and preparing for global warming; and improving our understanding of global warming. A climate change detection network consisting of stations operated by volunteers across all of Canada's climate zones is to be in place by 1996. Also, in recognition of the fact that climate change is a global problem and one that will affect Canada significantly, Canada participates in various international fora to combat climate change. Canada will pursue an International Framework Convention on Climate Change to be in place before mid 1992, and has committed $1 million to address special concerns of developing countries.

In recognition of the importance of the hydrologic cycle in potential climate change, the Inland Waters Directorate has formulated a strategy. The IWD Strategy for Addressing Atmospheric Issues (1991) states that expanded hydrometric monitoring is a fundamental need that involves the improvement of the hydrometric network density, of its ecosystem representation, particularly in the North, and of water quality/quantity integration. Also relevant is new and improved instrumentation and methodologies, including remote sensing. Furthermore, multidisciplinary studies are required in priority regions such as the North, the Fraser River estuary, the Prairies, the Great Lakes, James Bay, and the Atlantic coast. Commencing in 1991-1992, goals for the Directorate as regards global warming will be to: identify and assess potential impacts of climate change on the hydrological cycle, aquatic ecosystems, regional water resources, and related human activities; develop and implement tools and techniques for monitoring and detecting effects of climate change on freshwater

ecosystems and the role of the hydrosphere; and identify appropriate options for responding to the most serious negative effects of climate change on the freshwater environment and society (ie: on northern permafrost zones and Great Lakes water supply and use). Global warming is the issue identified of highest priority, followed by acidification, airborne toxins, stratospheric ozone depletion, and tropospheric ozone.

WRB Role in Climate Change

WRB can provide a long-term network of hydrometric and sediment stations with the capability of providing data necessary to quantify the areal and temporal effects of climate change on water quantity, sediment, and river morphology. Unregulated or natural sites subject to minimal human alteration, with long data records, would be most useful. Historical data stored in the national database HYDAT are available. It would be necessary, however, to quantify human activity that could influence the flow and sediment regime--the ability to depict basin changes over long periods may be difficult and even impossible. The establishment of several index basins with minimum human intervention in the foreseeable future would be required. Nevertheless, water quantity data currently are used for modelling scenarios of impacts and response strategies.

Present WRB activities of relevance to climate change and potential activities are outlined below.

Present Activities

- Under the IWD Strategy for Addressing Atmospheric Issues and towards the goals of the Green Plan, WRB HQ is committed to work with WRB Ontario Region on a project to assess hydrometric networks and data to determine their adequacy for detection of effects of climate change. Similar investigative work on climate change from the Atlantic and Pacific and Yukon Regions can be incorporated. WRB has data from 4389 active and discontinued, unregulated sites, 2175 of which are still active. More importantly, there are 17 unregulated stations with 60 years or more data, 88 with 50 or more years, and 174 with 40 or more years of data. However, the degree of human intervention and how it has varied over the period of observation for each basin has not been assessed. WRB will coordinate its efforts with the Atmospheric Environment Service, which also is establishing such a network.

- Hydrometric gauge sites are being utilized in cooperation with the Atmospheric Environment Service (AES) and using our data collection platforms (DCPs) to monitor weather parameters at a number of remote (Northern) areas to fill in gaps of weather and hydrometeorological data.

- Hydrometric data are used in climate change studies. An example is the study done by AES and the National Hydrology Research Centre on Possible Impacts of Climatic Warming Scenarios on Water Resources in the Saskatchewan River Subbasin (1989). Another example is the

generation of (mean annual) flows on a large square grid basis for use with global change models (GCMs) (Institute of Hydrology, Wallingford, United Kingdom).

Potential Activities

- Initiate cooperative studies to identify stations that should be preserved over the long-term in order to assess the effects of climate change on streamflow regimes. The termination of stations during periods of resource constraints continues to erode the long-term network necessary for such work. In British Columbia and the Yukon, for example, there are approximately 60 natural flow stations with more than 35 years of record, but only about 15 of these stations are designated to provide long-term information for HYDAT, the national data base. BC Water Management Branch and BC Hydro have shown interest in cost-sharing the design and operation of network segments related to climate change.

- Reinstate the WRB Bench Mark basin program where sites were selected across Canada, at which no disturbances were likely to take place, and collection activities were to run for an indefinite period in conjunction with the collection of meteorological data. The data could be analyzed to determine trends, etc. Alberta's site, for example, was in Banff National Park. However, more sites in each region covering the major geographical features are required.

- Define a theoretical network (existing and nev stations) necessary to evaluate the potential adaptations of water uses to offset the effects of changing precipitation and runoff patterns in particular regions. Possible collaborators are the Atmospheric Environment Service, the provincial water management branches, agriculture and irrigation agencies, hydro companies, groundwater agencies, the National Hydrology Research Centre, and universities.

- Modify the orientation of the sediment program to include information relating to climate change. A first area of activity might be in the North where the effects of climate change are expected to be amplified and basins have a high potential to remain pristine. Permafrost melt can be separated from other runoff components through identification of suspended sediment components associated with permafrost zones and through the use of environmental isotopes. Studies could be undertaken to design a sediment collection program that would provide optimum indicators. Possible collaborators include the National Hydrology Research Centre, the University of British Columbia, as well as other universities.

- Increase cooperation with other agencies to reduce duplication of effort as regards climate change studies. For example, the British Columbia Hydrometeorological Network Co-ordinating Committee includes BC Water Management and Air Management Branches, the Atmospheric Environment Service, and BC Hydro. It provides WRB contact with a

number of interested collaborators. The BC Water Management and Air Management Branches with BC Hydro, for example, provided funding for preliminary studies of climate change carried out in conjunction with the National Hydrology Research Centre.

- Identify weaknesses or gaps that exist in the national network pertaining to the coverage of water resources for climate change purposes. Such an identification process should inherently consider the ability to monitor other processes of the hydrological cycle. Consultation with the Atmospheric Environment Service and other monitoring agencies should be done.

- Investigate the utility of remote sensing and geographic information system (GIS) techniques to compliment current activities with regards to the utility of hydrometric data for climate change studies.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: DRINKING WATER

Significance

Drinking water is essential for life, but is increasingly threatened by inadequate quality and quantity. The issue therefore is linked to ambient water quality and water supply. Seventy four percent of water used for domestic purposes in Canada is surface water and 26 percent is groundwater.

The increasing number of potentially toxic substances detected in drinking water has heightened public concern. In the Great Lakes basin where 35 percent of Canadians live, toxins threaten drinking water and have become the single most important issue for the Lakes. Municipalities throughout Canada, however, steadfastly defend the quality of water being supplied.

Canada has an abundance of water, but its distribution causes local supply problems. While Canada has seven percent of the world's land mass and nine percent of the world's renewable water resources, 60 percent of the freshwater drains northward while 90 percent of the Canadian population lives within 300 kilometres of the southern border. This inequality of distribution results in water-short regions, the scarceness being exacerbated during drought conditions. Areas which are vulnerable include the interior of British Columbia, the southern Prairies, and the high Arctic. For example, water withdrawals from the North Saskatchevan, South Saskatchevan, Milk, and Red-Assiniboine River basins of the southern Prairies now approach their reliable supply limits (supplies available 90 percent of the time). Furthermore, while the Great Lakes is the world's largest freshwater lake system, some off-lake areas of southern Ontario such as Kitchener-Waterloo experience periodic and even chronic water shortage. In short, supplies of drinking water are ultimately affected by population concentrations and inequality in distribution of water.

The amount of water used by Canadians that is of drinking water quality is large compared to other countries. The average Canadian uses 350 litres of water per day compared to 140 litres for the average European. Canadian withdrawals from water bodies are about double the worldwide average. Thus, excessive water demand in addition to water quantity and its distribution factors into the supply of drinking water in the country.

Federal Involvement

Protection and restoration of Canada's drinking water is a shared responsibility of federal, provincial, and municipal governments. Health and Welfare Canada is the lead agency for the federal government.

One of 25 specific policy statements of the Federal Water Policy (1987) is on safe drinking water. It states that "the federal government is committed to ensuring safe drinking water within areas under its jurisdiction and to promoting and encouraging a consistent approach to protection and improvement of the

nation's drinking water...." In addition, Guidelines for Canadian Drinking Water Quality are periodically revised and published, most recently in 1990, and are based on the work of a federal-provincial advisory committee. Environment Canada is updating its guidelines for agricultural livestock watering. Issue papers on various chemicals in water are produced and research is undertaken on drinking water treatment processes, as examples. The Water Quality Branch of the Inland Waters Directorate, Environment Canada, also produces guidelines for freshwater.

Under the Green Plan (1990), the federal government will introduce a Drinking Water Safety Act in 1991. The Act will provide for the development of quality criteria for materials used in contact with water, chemicals used in water treatment and point-of-use water treatment devices. Also under the Green Plan, the government will significantly accelerate the provision of water and sewer systems to Indian reserves in order to address health and safety problems. It will also sponsor a national conference in cooperation with the provinces, communities and the private sector to promote wiser water use through improved demand management, realistic pricing and the development and application of water conservation technologies.

WRB Role in Drinking Water

Hydrometric data provide information on the water supply available for use, and as such are applicable to the design of drinking water facilities. After use and subsequent treatment, water quantity and sediment data are collected to monitor discharge from sewage treatment plants. Streamflow and sediment data are used in regulatory measures with regard to amounts of effluent that can be released.

Present WRB activities of relevance to drinking water programs and potential activities are outlined below.

Present Activity

- About seven percent, or an estimated 190 hydrometric stations are used for water supply and sanitation purposes.

- WRB collects surface water samples of inflow and outflow for sewage treatment lagoons in support of provincial Ministry of Environment programs (ie. Ontario).

- Data from approximately 50 sites in Alberta, for example, are directly used for drinking water study purposes. A much larger portion of the network (300 sites) is utilized in water availability studies. In addition, there are occasions when WRB staff in Alberta and Ontario, as examples, are called upon to take direct measurements of effluents, inflows, and internal distributions within treatment plants.

Potential Activity

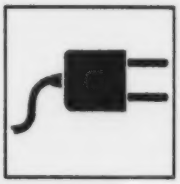
- Assume greater responsibility in the overall collection and analysis of samples by carrying out basic analysis of water quality in the field before sending samples to laboratories. Testing could include dissolved oxygen, temperature, transparency, conductivity, and pH. Water and sediment issues would be of relevance.

- WRB's expertise in the field of streamflow measurement and monitoring could be effectively utilized in the monitoring and measurement of intakes, outflows, internal distribution, etc., of water treatment facilities to ensure these plants are being operated in an environmentally effective manner.

- Become involved in the monitoring of groundwater quantity and quality. After some training WRB expertise could be applied to groundwater, but the equipment and computation changes could have significant resource implications. They would not be significant if only groundwater levels are involved, but they would be significant if they encompass aquifer yields, sampling for quality, or water quality analysis. Studies could encompass transport of point contamination through groundwater to receiving waterways.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: ENERGY

Significance



While energy is vital to economic development, the production, transmission, and use of energy can cause serious environmental problems.

Some forms of energy, which include nuclear, fossil fuels (coal, oil, gas), and hydropower, can be more damaging to the environment than others. Disposal of by-products of nuclear power pose threats of radiation, while coal and oil contribute to the greenhouse effect and acid rain. Natural gas also contributes to the greenhouse effect, but is considered to be "cleaner" product than coal and oil. While hydroelectric power development makes use of a renewable resource, flooding, loss of wildlife and fish habitat, loss of land and land-based resources, erosion, sedimentation, nutrient accumulation, and other impacts can result from the damming of watercourses. Solar and wind power are the most environmentally-friendly, but current costs are too high for economic power production.

Water is an important element in power production. Nuclear and thermal power plants require large quantities of water for cooling. Most plants employ a cooling system where water is extracted and returned to the source in essentially the same quantity, but at a higher temperature. In addition to surface water, groundwater is now being used for cooling purposes in nuclear and thermal plants. However, water is most important in the production of hydroelectric power. In 1988, hydropower provided 63 percent of electricity in Canada, with the remainder supplied by nuclear and conventional thermal power plants. For Newfoundland, Quebec, Manitoba, British Columbia, and the Yukon the figures are over 94 percent. In Canada water is the most important element in electrical energy production.

The increasing costs of fossil fuels render hydropower more attractive. However, while about one-third of Canada's hydro potential is developed, the majority of undeveloped sites may be uneconomic, environmentally incompatible, or of small capacity or low-head. Development of these sources depend on technological advances, economics, and acceptance of alternate forms of energy. Energy Probe believes that Canadian energy needs could be met by hydroelectric power alone if energy use was as efficient here as it is in Sweden or the United States, a hypothesis that Ontario Hydro disputes. Nevertheless, some small-scale hydro units may be economically feasible for isolated communities. In Alberta, for example, low-head power development is becoming very economic, particularly at existing reservoirs that were built for purposes other than hydroelectric power generation.

Canada's per capita use of energy is one of the highest in the world. Furthermore, in 1985 Canada was the world's largest hydroelectric producer.

At the consultative sessions of the Green Plan, Canadians felt strongly that research into alternate forms of energy, energy conservation, and energy

efficiency should be a high priority. It was felt that use of solar energy and small-scale hydroelectric energy should be further explored.

Federal Involvement

The provinces are responsible for electric energy production; the federal government, in cooperation with the territorial governments, has responsibility for the North.

One of 25 specific policy statements of the Federal Water Policy (1987) is on hydroelectric energy development. Energy, Mines and Resources Canada is the lead federal agency for energy matters. It sponsors research and development initiatives in this field, in small-scale and low-head hydro including tidal power, for example. Energy, Mines, and Resources and Environment Canada are involved in the compilation and dissemination of national statistics on dams and electric power in Canada. Indian and Northern Affairs Canada is involved in Native concerns with regard to reserve flooding, impacts on hunting, fishing and trapping, and water quality vis-a-vis hydro development.

Under the Green Plan (1990), the government will table a National Energy Efficiency and Alternative Energy Act dealing with energy use, improve energy efficiency in buildings and equipment, improve energy efficiency of Canada's transportation system, work with industry, development of alternative fuels and energy sources, inform Canadians how they can save energy, etc. Hydropower is not specifically targeted in any of the initiatives.

WRB Role in Energy

Since information on the availability and reliability of water is necessary for the design, construction, and operation of energy-producing facilities, particularly hydroelectric power, WRB has a role to play. Hydroelectric power production itself depends on the flow and head available in a river reach. Water quantity data are essential for the operation of the facilities; knowledge of the pattern of the availability of water throughout the year is important for optimal planning of energy production. A conservative estimate of the value of hydrometric data for design of hydroelectric projects is 5 percent of total construction expenditure, or about $64.3 million per year (data from 1977). The ability to transfer information regarding the availability and the extreme characteristics of water is important for both the design and planning of hydroelectric facilities.

One of the most extensive uses of sediment data is for reservoir studies, for which suspended and bedload sediment data are needed for reservoir design. The data are used since siltation of reservoirs built for flow control or generation of hydroelectric power can reduce reservoir capacity. Knowledge of the density of deposited sediment requires relative percentages of sand, silt, clay. Furthermore, suspended sediment can wear on turbines and penstocks at hydropower installations. Reservoir design is a good example of the use of historic data for planning purposes.

Present WRB activities of relevance to energy programs and potential activities are outlined below.

Present Activities

- About 12 percent, or an estimated 330 hydrometric stations operated by the Water Survey of Canada are used for energy purposes.

- In Alberta, for example, 30 real-time WRB data sites are directly used by reservoir operators in the day-to-day decision-making process. These are not only used by operators in Alberta, but, because of the interprovincial flow aspects of the major streams arising in Alberta, also by Saskatchewan and Manitoba operators as well.

- WRB analytical software such as consolidated frequency analysis (CFA) is used by designers of spillways for hydroelectric facilities.

- Regionalization techniques are developed and are made available to the hydrologic community. They help to translate site-specific data into information for a region or area.

Potential Activities

- Since water is used as a coolant in energy production, WRB could expand its functions to include monitoring of surface water temperatures.

- Since groundwater is now being used as a coolant to nuclear and thermal plants, WRB could expand its functions to include monitoring of groundwater through the Federal-Provincial Water Quantity Cost Share Agreements.

- Expand the real-time network that provides water data instantly to enable hydroelectric operators to make more better decisions.

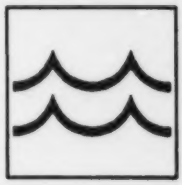
- Maintain information exchange and databases with not only power companies, but also non-power companies on potential projects. Some companies produce electrical energy for their internal consumption.

- Continual effort could be extended to transfer information to ungauged sites or sites with little or no data.

- Develop forecast models incorporating the latest technologies (digital radar, remote sensing).

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: FLOODS/DROUGHTS

Significance



Floods and droughts, both hydrologic extremes, can be devastating environmentally and economically.

Flooding is experienced to some degree in most of Canada. Damage is estimated to be $35.9 million annually (data from 1977). The average annual flooding and erosion damage along the Canadian shore of the Great Lakes is about $2 million (1987). Flooding in Canada is caused by torrential rainstorm events, by water backing-up behind ice jams, or by the rapid melting of the snow cover in the spring or early summer particularly when combined with rain.

While droughts are relatively rare in much of Canada, semi-arid areas are constantly susceptible. Droughts have been most severe in Canada in the Prairies and the valleys of British Columbia. Global warming would exacerbate the drought conditions of such interior regions. The 1980s saw droughts occurring throughout the Prairie provinces such that severe water shortages resulted in insufficient water for domestic purposes. Alternate sources of water had to be procured, including trucking, pipeline construction, development of alternate sources (groundwater), etc.

Federal Involvement

The Water Resources Branch and the Water Planning and Management Branch of the Inland Waters Directorate, Environment Canada, are the lead federal agencies for floods.

Two of the 25 specific policy statements of the Federal Water Policy (1987) are on floods and droughts. For flooding it states that "the federal government is committed to alleviating human suffering caused by floods and minimizing the costs of flood damages". Environment Canada manages the Flood Damage Reduction Program, established in 1975, the objective of which is to reduce flood damages. Identification of flood risk areas, floodplain mapping, flood forecasting and warning, flood-proofing, works to control flows and levels, acquisition of property, and easements or land use planning are examples of tasks undertaken under the agreement. Examples are the Canada-Manitoba Flood Protection Projects and the Mille Iles Flood Control Structure. All provinces except Prince Edward Island are part of the program; Prince Edward Island does not have serious flooding problems. The Northwest Territories have signed an agreement and negotiations are taking place with the Yukon government. By 1990 more than 150 sites had been designated and since the program is nearing completion, maintenance agreements will be signed with the provinces.

While federal involvement in flood forecasting is limited to basins of high national interest, data collected by federal agencies, including WRB, are vital to forecasting systems. An agreement exists with New Brunswick, with a proposal

for the Northwest Territories, for the development of flood forecasting centres. Once established, the provinces are responsible for maintaining a flood forecasting network, as has been done in the case of Manitoba.

Under the Green Plan (1990), the Government is committed to improve emergency preparedness within urban centres against flooding. Automated water-level monitoring equipment will be installed in streams above flood-prone, major urban centres by the end of 1994. Flood forecasting agreements with other parties will also be in place. The IWD Strategic Plan (1990) indicates that quantity and quality data will continue to be required for incorporation into state-of-the-art models. Participation in hydrologic and water quality modelling is required to ensure the proactive management of water, particularly with regards to emergency response and environmental impact assessment. Models and other engineering techniques are required so as to provide tools and information to form a sound basis for water management decision making.

For droughts, the federal government has stated its commitment to support the prairie provinces in drought management initiatives; it encourages demand management and conservation technology with a view to extending the use of limited supplies. Projects of the Prairie Farm Rehabilitation Administration (PFRA) of Agriculture Canada provide water to sustain and enhance agricultural production and infrastructure while providing waterfowl habitat enhancement. PFRA also produces comprehensive water supply condition reports and current briefings on drought potential for the prairie provinces on an ongoing basis. The National Hydrology Research Institute of the Inland Waters Directorate does research on drought, as does the Energy, Mines and Resources Canada Centre for Remote Sensing. A guidebook to water conservation in the home is being produced with a number of provinces. Two drought strategies are being prepared by several federal departments in cooperation with the provinces. The existing Federal Drought and Disaster Response of the PFRA is aimed primarily at agricultural interests, with some of this being adopted for a Drought Strategy Paper by Environment Canada. It addresses water supply and highlights the need for an integrated delivery of data and information between all federal and provincial interests with a view to more effective drought forecasting and monitoring.

WRB Role in Floods/Droughts

As indicated, WRB and the Water Planning and Management Branch are the lead federal agencies for flood matters.

Since floods and droughts are hydrologic extremes, WRB activities are fundamental for their forecasting, analyses of severity, and frequency. Real-time data are particularly useful for the first two activities, while historical data such as those stored in the national data base HYDAT are fundamental for all three activities.

Since the principal benefit of forecasting lies in the ability to floodproof, flood damages can be reduced between five and 15 percent. Flood damage prevention is estimated to be worth $3.6 million annually (data from 1977). A rough estimate of the value of hydrometric data for the design and construction for flood control is $2.9 million annually (1977). The network of WRB discharge

stations, particularly the real-time data stations, thus plays a crucial role in flood forecasting in Canada.

As droughts are a major factor in limiting habitat and reproductive success on an annual basis, forecasts of spring runoff are needed also to estimate spring pond numbers. Over longer time periods, real-time and long-term data are the foundations of drought mitigation and control, being used for regulation of reservoir supplies, to determine variability of supply, and management of irrigation waters. Thus, WRB data contribute to drought forecasting, for apportionment of water during drought conditions, as well as drought planning, impact studies, and ecosystem conservation.

Sediment plays a role both in flood and drought conditions. During flooding, the sediment concentrations are high and result in major siltation and erosion. A knowledge of the sediments during these occurrences help in the design of remedial works such as bank protection, sediment traps, etc. For drought, sediment data are utilized in the design of water intakes for alternate water supply development.

For both flood and drought response, real-time data and long-term records are important. The collection of long-term data at key sites and the ability to transfer information by regionalization techniques allows the estimation of the frequency of occurrence of floods and droughts. This is important for the Flood Damage Reduction Program and for the estimation of reliable water supplies during drought periods.

Present WRB activities of relevance to flood and drought programs and potential activities are outlined below.

Present Activities

- About 54 percent, or an estimated 1445 hydrometric stations are used for flow forecasting and floodplain management purposes. About 800 stations or one quarter of the total hydrometric network in Canada have some type of real-time data capability, crucial for flood-forecasting. Real-time data are retrieved directly by telephone or in some cases from the GOES system of satellites via three Direct Readout Ground Stations incorporated into the WRB computer network. These stations are operated jointly with the Atmospheric Environment Service of Environment Canada. An example of assistance provided concerning flooding is that using data for seven stations in the Northwest Territories WRB provides forecasts in the spring to flood prone communities, especially along the major Liard and Mackenzie River systems. Another example is that using data from 14 sites WRB provides a vital water level forecast program during each open water season along the entire 1600 km stretch of the Mackenzie River to ensure safe and efficient navigation of major shipping companies that supply essential supplies to remote communities along the River and oil exploration in the Beaufort Sea.

- WRB has a role under the Green Plan to establish water level equipment

above major urban centres for flood forecasting purposes.

- WRB plays a significant role in the development of hydrologic methods for the interpretation of hydrometric and meteorologic data. Various physically and statistically based models have been used in the analysis of extreme conditions. Several models, such as the HYDROTEL and TANK models, can be used in the interpretation on hydrometric data, the estimation of missing data, and the real-time forecasting of drought and flood flows.

- For drought, 1100 of the 2700 WRB hydrometric and sediment stations across Canada are located in the three Prairie provinces. Each year, outlooks for spring runoff are prepared by the three Prairie provinces, with streamflow data provided to the River Forecast Centre of Alberta Environment, the Hydrology Service of the Saskatchevan Water Corporation, and the Manitoba River Forecast Centre of Manitoba Natural Resources. The Prairie Farm Rehabilitation Administration prepares a quarterly report on water supply conditions and utilizes data from 30 selected hydrometric stations to ascertain the significance of the flows compared with long-term conditions. During severe drought conditions reports are prepared more frequently.

- Hydrometric data are used by the Prairie Provinces Water Board, to ensure that 50 percent of natural flows pass to downstream jurisdictions. Such apportionment becomes more important during times of drought, requiring that timely and accurate streamflow data be available. In Alberta, for example, about 80 stations are used in this monitoring.

- Interpretive reports on the occurrence of large flood events are prepared and distributed to the hydrological community.

Potential Activities

- In cooperation with the provinces and private companies, increase real-time data collection capability to better meet the needs for flood and drought forecasting.

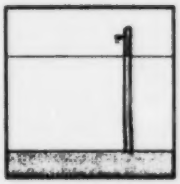
- Conduct network evaluation and planning exercises to identify strengths and weaknesses in the network and make recommendations regarding the moulding of the network for the forecasting and prediction of floods and droughts in Canada.

- Increase expertise in physically and statistically-based short and long-term forecasting for flood and drought periods.

- Increase involvement in the regional transferability of long-term information regarding the frequency of floods and droughts. This means translating site-specific data into information for a region or area.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: GROUNDWATER

Significance



Two-thirds of the world's freshwater is groundwater. At any one time groundwater represents about 37 times the total amount of water contained in rivers and lakes. This water is increasingly being relied upon for freshwater supplies, while at the same time is increasingly threatened by contamination.

In Canada, there is also more groundwater than surface water. In 1960, 10 percent of Canadians relied on groundwater for domestic uses. Now, the figure is 26 percent. However, in 1981 groundwater accounted for only four percent of total water usage, suggesting that groundwater is heavily relied upon for domestic consumption. Thirty eight percent of Canadian municipalities rely partly or totally on groundwater for their supplies; the population of Prince Edward Island relies entirely on groundwater for its domestic needs. Groundwater also sustains wetlands, streams, and lakes.

In Canada, there are no major problems with aquifer depletion because most major centres use surface water. Where groundwater is used (PEI and Kitchener-Waterloo, as examples), safe yields and water conservation are strived for. Where groundwater supplies have not met demand, these have been supplemented by surface water. Thus, groundwater quantity is not an issue of national significance.

Although groundwater has received only modest attention on a national scale because of the perceived abundance of surface water, groundwater quality is becoming an issue of increasing concern. Natural contamination occurs from overabundances of iron, manganese, and arsenic, as examples. Uses are threatened by natural or anthropogenic contamination. Sources of anthropogenic contamination are pesticides used in agriculture, leakage from chemical dumps and underground storage tanks, subsurface waste disposal, chemical spills. A single litre of gasoline on the ground result in the contamination of an aquifer. While groundwater purification may not be needed before use, once contaminated, not only is purification required, but purification of the aquifer is more difficult than purification of surface water.

In addition to groundwater contamination, topics of current focus within the groundwater field are recharge and rising aquifer levels. First, since unsustainable groundwater extraction leads to deterioration in water quality, increased pumping costs, and land subsidence, increased attention is being focussed on groundwater recharge. This is accomplished through natural seepage of rainwater or snowmelt, leaching from reservoirs, or mechanical transmission of surface water through boreholes. Conversely, rising aquifer levels are proving to be problematic in cities around the world. A consequence of new technology for water supply and use is that less groundwater is extracted, causing a rise in the groundwater table closer to pre-industrial, natural levels. London, Birmingham, Nottingham, Liverpool, Paris, New York, and Tokyo are examples of where this problem is coming to the forefront. Thus, within the

discipline, insufficient and excess groundwater, as well as groundwater contamination, are issues to be addressed in the 1990s. The ability to model contaminant movement in groundwater is also an important issue.

Federal Involvement

One of 25 specific policy statements of the Federal Water Policy (1987) is on groundwater contamination. It states that "the federal government is committed to the preservation and enhancement of the ground water resource for the beneficial uses of present and future generations".

In 1990 Environment Canada initiated work, in consultation with other agencies and sectors, on a strategy for implementation of the Groundwater Contamination Policy. An overall federal groundwater strategy will be developed. Improvements have been made to the data base required to support federal groundwater management, and data reports on regional and national groundwater contamination. International transboundary water quality related to groundwater has been monitored and maintained at acceptable levels under several transboundary agreements. Interprovincial groundwater quality concerns are kept under review by agencies such as the Prairie Provinces Water Board.

Under the Green Plan (1990), the federal government will publish a series of guidelines and codes of practice to help local authorities deal with groundwater problems.

To date, however, groundwater monitoring and contamination has not been addressed in a coordinated, systematic manner.

WRB Role in Groundwater

Although surface water is linked to groundwater movement and availability in a region, the WRB role in groundwater management currently is minimal. Information from stream gauging stations (recessional flows) can be used in assessing groundwater supplies and their quality. Present WRB activities of relevance to groundwater programs and potential activities are outlined below.

Present Activities

- Under the federal-provincial agreements on water quantity surveys, WRB staff in New Brunswick and Prince Edward Island operate recording instruments and process data for a number of groundwater wells.

Potential Activities

- Adopt a stronger role in groundwater monitoring, for quantity and/or quality. Federal-provincial agreements could be expanded to include water level measurements of groundwater. Resource implications would not be significant if only levels are involved, but they would be

significant if they encompass aquifer yields, sampling for quality, and water quality analysis.

- Ecosystem studies require knowledge regarding both groundwater and surface water. The quality/quantity and the movement of groundwater and contaminants therein will increase in importance. Three dimensional modelling of groundwater systems, contaminant transport in saturated and unsaturated media, and "age" of water studies could be pursued. Knowledge of how contaminants evolve and are transported in the hydrologic cycle is of importance for various purposes. Both groundwater and surface water supplies can be effected by aquifer contamination.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: INTERJURISDICTIONAL ISSUES

Significance

Not only are interjurisdictional matters important when there are competing uses for water contained in the thousands of Canadian lakes and rivers that cross provincial and international boundaries, but the political structure of Canada makes interjurisdictional issues important to the management of water resources.

Responsibility for water management is shared by the federal, provincial, and municipal governments, with the provinces being responsible overall. Federal responsibilities include water in national parks, Indian reserves, federal lands, international waters, and that in the Northwest and Yukon Territories. Shared federal-provincial responsibilities encompass interprovincial water issues, agriculture, health, and significant national water issues such as interbasin transfers.

Federal Involvement

Numerous committees exist through which the federal government interacts with the provinces concerning the environment and water resources. The prominent example is the Canadian Council of Ministers of the Environment (CCME).

One of 25 specific policy statements of the Federal Water Policy (1987) is on potential interjurisdictional water conflicts, responses to which are outlined below.

Federal-provincial/territorial agreements relevant to water resources may be divided into three categories: regulation, apportionment, monitoring and survey programs; water management programs; and the flood damage reduction program. Dozens of agreements and programs exist. Examples are the Water Quantity Survey Agreements, Water Quality Monitoring Agreements, the Prairies Provinces Water Board, the Lake of the Woods Control Board, and the Flood Damage Reduction Program. The Boundary Waters Treaty and the Canada-US Agreement on Great Lakes Water Quality are examples of agreements that exist on the international level.

The federal government advocates exercising caution in considering major interbasin transfers and endorses other, less disruptive alternatives such as demand management and water conservation. Environment Canada is preparing a background document on criteria for the environmental assessment of interbasin transfers of water within Canada. The federal government introduced the Canada Water Preservation Act in Parliament in 1988, designed to forbid large-scale export of water by diversion and establish conditions for small-scale export of water. While the Bill was not passed before Parliament finished its session that year, federal and provincial governments cooperate to ensure that proposed small-scale exports of water are not environmentally damaging and are conducted in accordance with federal procedures of international trade and environmental

protection.

Under the Green Plan (1990), commitments were made to numerous projects that will require interjurisdictional cooperation. One of Canada's goals is to strengthen existing environmental partnerships within Canada, while also building new ones. The federal government will initiate efforts to harmonize environmental legislation, policies, and programs across all political jurisdiction. Of most significance to water, the establishment of water level monitoring sites above major urban centres for flood forecasting is one example. Another example is that in addition to clean-up measures for the St. Lawrence and the Great Lakes, Canada will work with the United States to develop a bilateral action plan for comprehensive pollution prevention in these basins.

WRB Role in Interjurisdictional Issues

Interjurisdictional agreements are fundamental to the work carried out by WRB. WRB is responsible for and participates in numerous agreements. WRB is considered to be an unbiased agency usually accepted by all parties involved in interjurisdictional problems. Present and potential WRB activities with jurisdictional components are too numerous to list. Examples are outlined below.

Present Activities

- WRB is the principal agency responsible for the federal-provincial/territorial Water Quantity Survey Agreements. The Branch operates about 2700 of 3300 hydrometric stations in Canada for the Provinces, etc., under the Agreements. The objectives of the agreements are to maintain a viable and efficient national hydrometric network and to give recognition to joint federal and provincial responsibilities in this activity. Mutual benefits include efficient and cost-effective operation of networks, and standardization of data on a national basis.

- WSC operates about 95 "international gauging stations" for use under the Boundary Waters Treaty, Great Lakes Water Quality Agreement, etc., to fulfil Canada-US obligations.

- Streamflow, water level, and related data are used by the Lake of the Woods Control Board. Established in 1919 between Canada, Ontario, Manitoba, and the USA, its objective is to control and regulate certain major waterways in the Winnipeg River drainage basin to achieve water flow and level conditions that are reasonably acceptable to the various interests.

- WRB data are used by the Prairie Provinces Water Board, between Canada, Alberta, Manitoba, and Saskatchewan, for the equitable apportionment of eastward flowing interprovincial prairie waters. The agreement ensures that one-half the natural eastward flow of waters arising in or flowing through Alberta is reserved for Saskatchewan, and that one-half the eastward flow arising in or flowing through Saskatchewan is

reserved for Manitoba. Natural flows are calculated by the WRB using a computer model on an annual basis for eight streams. In Alberta for example, WSC operates about 80 stations for this purpose.

- For the Flood Damage Reduction Program, WRB data, a frequency analysis package, and regionalization approaches are used to delineate flood plains and to determine the 100-year floods, ie: the areas at risk and the magnitudes of the risks. Flood damage prevention is estimated to be worth $3.6 million annually (data from 1977).

- WRB has a role under the Green Plan to establish water level equipment above major urban centres for flood forecasting purposes.

- Under the Green Plan, WRB is working with the Northwest and Yukon Territories to expand and modernize hydrometric stations in all major northern water basins and provide technical advice and guidance on major basin studies. For example, snow and sediment monitoring programs for the Mackenzie River basin will be developed and implemented to augment the water quantity network in cooperation with the Atmospheric Environment Service and Indian and Northern Affairs Canada.

Potential Activities

- Through the federal-provincial agreements, WRB take a stronger role in the integration of water quantity, quality, and sediment networks throughout Canada.

- Expand federal-provincial agreements to include groundwater monitoring.

- Adjust networks to ensure any change in water use and quality in interjurisdictional basins are accounted for.

- Obtain expertise in groundwater modelling to support interjurisdictional balancing of a basin's water.

- Increase the integration of data collection and interpretative capabilities to deal with the complex demands of integrated interjurisdictional environmental management.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: SCIENCE AND TECHNOLOGY

Significance

Due to Canada's tremendous resource base, science and technology are fundamental to the country's economic health. However, the lov level of such activity in countries such as Canada, the United States of America, and Britain relative to other industrialized countries is cause for concern.

In the consultative sessions for the Green Plan on science and technology, Canadians expressed concern about Canada's limited research and technology capacity. More specific to the concerns of WRB, some Canadians were unsatisfied with the amount, quality, and accessibility of both basic environmental data and interpretations of that data. Baseline data sources were felt to be inadequate, with declining funding and short-term priorities eroding the baseline dataset.

Federal Involvement

The federal government is the largest single source of funding of science and technology activities in Canada. During the fiscal year 1987-1988 it spent about $4 billion on such activities, representing about 11 percent of total non-statutory expenditures. The government employs approximately 17,000 people in research, or 25 percent of the national total (1987-1988). Among the federal agencies that undertake research in the fields of water resources and hydrology, the National Water Research Institute and National Hydrology Research Institute of the Inland Waters Directorate are devoted to the task.

The promotion of Canadian science and technology has been fundamental to the federal approach for a number of years. One of five strategies of the Federal Water Policy (1987) is on science leadership, while of 25 specific policy statements two are on research leadership and technological needs. The strategy recognizes that scientific and socio-economic research, technological development and data collection are vital tools for dealing with resource problems and that effective water resources management is dependent on a scientifically sound knowledge base.

Under the Green Plan (1990), the federal government is committed to increase expenditure in water-related science and technology, in cooperation with provinces and industry. It is launching a five-year Environmental Science and Technology Action Plan that will explore nev directions in solving our domestic and global problems. The Plan will support the Canadian Global Change Program, fund scholarships in the environmental sciences, and work with provinces and private sector to support environmental technologies. The goal is to strengthen environmental science and technology, with special emphasis on understanding regional ecosystems.

WRB Role in Science and Technology

The activities of WRB depend heavily on science and technology. The Branch not only uses science and technology in its programs, but further develops them.

Present WRB activities of relevance to science and technology, and potential activities are outlined below.

Present Activities

- WRB develops and tests hydrometric equipment, for use at the approximately 2700 of 3300 hydrometric stations in Canada it operates and others. Examples are flow meters for measurement of flow under ice, testing of pressure transducers for the measurement of stage, perfection of a moving boat method for the measurement of flow, testing of acoustic flow meters for velocity measurements, and provisions for other environmental parameters on our data loggers.

- WRB adapts sediment equipment developed by the United States Geological Survey (USGS) for its uses and conditions, which subsequently may be incorporated into USGS designs.

- Computer software known as COMPUMOD is being developed with private industry to function as the operating system for use by technical staff across Canada to reduce time-intensive methods. It will encompass state-of-the-art data handling, processing, and analysis capabilities. Some of the demands being made of the software will result in capabilities not yet available on the software market.

- The Branch provides expertise to scientific studies, such as that being conducted for the St. Lawrence River at the Centre St. Laurent.

- WRB has a scientifically sound knowledge base in HYDAT, the national hydrometric database. Data for 2700 current and 4000 discontinued hydrometric stations, and 200 current and 600 discontinued sediment stations are stored in this database.

- Scientifically sound technologies for analyzing hydrometric and sediment data have been developed and analytical packages are made available to assist in the interpretation of hydrometric and sediment data.

- WRB formulates national standards based on current technology for hydrometric and sediment data collection, data analysis and control, and measurements of flow under ice.

- Artificial intelligence/expert systems are being investigated for application in the field program, more specifically to assist the technologist in the collection of data and information.

- The Branch conducts or participates in hydrometric and hydrologic

research projects as part of integrated research programs (ie: Experiments Lakes, the Northern Oil and Gas Program).

Potential Activities

- While development of hydrometric equipment and automation of sediment laboratories occurs or will occur through the WRB modernization initiative known as Project 2000, automated methods also could be developed for the collection of suspended sediment samples or sensing.

- Investigate accuracy levels provided by current hydrometric methods and standards and modify/improve procedures and equipment.

- Review WRB technical and scientific accomplishments on a regular basis (ie. annually) and make the effort to publish articles and/or give conference presentations of those accomplishments that could be relevant to science and technology. Likewise, time and financial allowances must be made for requests for information/help resulting from such work.

- Strengthen interpretive skills and expertise and continue to develop analytical software for the analysis of environmental data.

- Encourage support of government to artificial intelligence and expert systems projects in this area of study.

- Have greater emphasis on the use of hydrometric and sediment data for the understanding of regional ecosystems and the hydrological cycle.

- Assist in the design and development of forecast methodologies for major urban centres in conjunction with the Atmospheric Environment Service (AES), other federal agencies, provincial governments, etc.

- Continue to develop methods of augmenting hydrometric data by regionalization of site-specific data to information for regions or areas.

- Further develop equipment such as data loggers and instruments for integrated environmental monitoring.

- Endeavour to obtain knowledge and expertise about the use of advanced scientific methods, such as environmental isotopes and groundwater modelling, for use in ecosystem studies.

- Strengthen links between water quality and sediment transportation as regards environmental issues.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: SOIL EROSION/SALINITY

Significance

Not only do soil erosion and salinity adversely affect economic activity, but soil erosion from agricultural land is the major cause of non-point source pollution. The eroded material can contain large concentrations of fertilizers, herbicides, and pesticides, not to mention other anthropogenic contaminants and livestock waste. The sediment can place a heavy demand on oxygen, threatening aquatic life in streams. The chemical make-up of the sediment (particles in suspension or deposited and water (soluble compounds) directly influence aquatic life and can have adverse effects on the carbon cycle (food chain) of regional ecosystems. Soil erosion has been referred to as a "quiet crisis in the world economy".

Erosion occurs throughout Canada. British Columbia and the Atlantic provinces are more susceptible to erosion from water because of significant amounts of runoff, as opposed to the Prairies where, with high evaporation and low runoff, aeolian processes prevail. The Great Lakes account for four percent of the total length of Canada's coasts; average annual flooding and erosion damage along the Canadian shore is about $2 million.

The most serious damage to soils by irrigation stems from waterlogging and salinization of the soils. Both can kill crops. In some cases, where sufficient amounts of water are present, salts can accumulate in lake basins, creating saline lakes. The salts may be derived from rocks, the water supply, etc. In water courses, in the Colorado River, for example, high concentrations of salts result from increased use of water in the upper basin with consequent decrease in the dilution of the salt load in the downstream areas. The increased salinity causes substantial stress to irrigated crops, and increased corrosion of water conveyance and handling facilities. It is unclear whether salinity in rivers causes problems in Canada. However, the majority of saline soils and lakes in Canada are found in southern Saskatchewan and Alberta, where potential evaporation rates are high, concentrating salts near the surface of the soil profile, and precipitation is insufficient to flush these salts out of the soil.

Federal Involvement

While shoreline erosion is one of 25 specific policy statements of the Federal Water Policy (1987), the federal government bears no responsibility for and cannot regulate erosion. While it does not participate in remedial measures, it supports the concept of discouraging settlement and investment in areas subject to natural erosion. It cooperates with the provinces in the National Soil Conservation Program designed to promote sustainable production practices. It will act on erosion caused by wave action from commercial shipping or the existence of a federal structure in the waterway or where federal facilities are at risk. Under the Canada/Ontario Flood Damage Reduction Program, the Great Lakes shoreline is being mapped and hazard areas defined. Water levels of the

Great Lakes are being investigated by Environment Canada.

Action under the Green Plan (1990) include extension of the National Soil Conservation Program, establishment of permanent cover on environmentally sensitive lands, development of shelterbelts, research on soil-conserving production systems, and creation of a new Eastern Canada Soil Conservation Centre.

WRB Role in Soil Erosion/Salinity

WRB hydrometric and sediment data are useful to determine the rate of erosion, timing, and contaminants carried from agricultural basins by the sediment to water bodies. An example of such a contribution is that done by the Western and Northern Region on sediment impacts of farming on the Saskatchewan River Basin. Present WRB activities of relevance to soil erosion and salinity, and potential activities are outlined below.

Present Activities

- WRB participates in special programs with other federal and provincial agencies to investigate the effects of varying soil tillage techniques on rural runoff quality and quantity.

- Sediment analysis reports are prepared for long-term sediment monitoring sites that provide collected data in readily usable formats to scientists and others involved in erosion studies. One example is a source study contracted to Alberta Research Council for the Oldman River basin.

Potential Activities

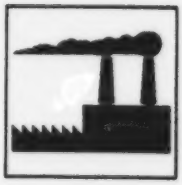
- Increased cooperation with water quality agencies to monitor discharge, sediment, and water quality to control contamination. Included could be the determination of the fate, source, and transfer of sediment particles with the attached toxins. Monitoring of toxins in solute will also be required. Specialized sampling equipment, improvements to monitoring procedures, and modelling of flow regime and sediment discharge will be required.

- In conjunction with the Water Quality Branch, expand collection and analysis of sediment samples to include the area of toxic substances carried in solute and by suspended and bottom sediments.

- Cooperative studies with agricultural agencies in irrigation salinity studies.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: TOXIC SUBSTANCES

Significance



Toxic substances can cause death, disease, behavioural abnormalities, cancer, genetic mutations, reproductive malfunctions, or physical deformations in any organism. They can be harmful to life even at very low concentrations. One litre of oil alone can contaminate up to two million litres of water. Toxins can persist (resist biological or chemical transformation), bio-accumulate (and transfer up the food chain), or combine with other substances, exacerbating the threat.

Sources of toxins include industrial manufacturing, fuel combustion, waste disposal, agricultural drainage, and urban runoff. Acid precipitation also can increase the release of toxic metal concentrations into the environment. Pathways to the aquatic environment may be point sources, such as outfalls, or diffuse, such as non-point agricultural runoff or atmospheric deposition.

Human exposure to contaminants occurs through ingestion of food, water, inhalation, and skin exposure. It has been estimated that percentages of total human exposure to toxins are 85 from food, 11 from water, and four percent from inhalation.

In water, toxins can be found both in free form and attached to sediment particles. In large bodies of water, the particulate phase is particularly important because of the long retention time of the toxins--contaminated bottom sediments are a major source of toxins to the overlying waters and biota of lakes. The main factors governing the attraction of toxic organic chemicals to sediment particles are the solubility of the substance, concentration of the substance, concentration of the sediment, type of sediments, concentration of other chemicals and ions in solution, and temperature. Large amounts of toxic substances also may be adhered to sediment particles in rivers. Thus, sediments play an important role in determining the amount of toxic chemicals found in the water environment.

All of Canada is potentially threatened by toxins. There are more than 32,000 chemicals in use in Canada, and fertilizer/pesticide sales increased 350 percent since 1966. About 500 pesticides alone are registered in Canada. In the Great Lakes basin, where 35 percent of Canadians live, over 800 toxic chemicals have been found in the water, 350 of them persistent. Contamination of human and animal life in the North is alarming.

Canada is also threatened by toxins produced and used in other countries. Up to 100,000 chemicals are estimated to be in use worldwide, with about 1,000 new ones entering the market each year. For North America the estimate is over 60,000 chemicals in commercial use, and with the combination of chemicals the number is probably greater than 200,000. Some of these may be transported to Canada, as in the case of acid precipitation, by air or water circulation.

Some progress has been made, however. Phosphorous loadings in the Great Lakes and the St. Lawrence down to Cornwall were reduced 11 percent between 1976 and 1982. Concentrations of DDT in lake trout have decreased in lakes Superior, Michigan, Erie, and Ontario. Herring gull eggs indicated a significant decline in a wide range of contaminants between 1974 and 1986.

Federal Involvement

No single federal agency is responsible for combatting toxic substances in Canada. Those involved include Environment Canada, Agriculture Canada, and Health and Welfare Canada.

Specific to water, the Great Lakes Water Quality Agreement (1978) makes provisions for the control of toxic substances entering the Great Lakes. The main goal of its 1987 Protocol is to advance the cleanup of the Lakes by dealing with all sources of pollution entering them. The Great Lakes Action Plan announced in October 1989 allocates an additional $125 million of federal funds to multiparty efforts to clean up the Lakes and study the effects of the contaminants on human health. The Great Lakes University Research Fund (GLURF) was established in 1990, which gives $1 million annually over four years for university research on the Great Lakes.

One of 25 specific policy statements of the Federal Water Policy (1987) is the management of toxic chemicals, the resulting initiatives of which are outlined below.

The Canadian Environmental Protection Act (CEPA, 1988) provides for a comprehensive, life-cycle approach to management of toxic chemicals. Within this framework, a Priority Substances List is used to identify chemicals for which impacts need to be assessed urgently, and for which Environment Canada and Health and Welfare Canada investigate the health and environmental hazards. Environmental quality guidelines and objectives often result from such investigations. To enforce CEPA, Environment Canada has established investigative units in each of its regional offices. CEPA is now responsible for regulating nutrient inputs to Canadian water courses.

Under the Pest Control Products Act, Agriculture Canada regulates pesticides by ensuring the safety, merit, and value of pesticides. Under the Fertilizers Act, Agriculture Canada ensures that fertilizers are safe, pure, potent, efficacious, and labelled. Energy, Mines and Resources Canada issued departmental policies and procedures on the management of dangerous substances.

The St. Lawrence River Action Plan commits $110 million over a five-year period as the federal share for cleanup and protection of this river. The Centre Saint-Laurent has been established as a federal-provincial initiative to study the problems of the river.

Under the Green Plan (1990), the goal with respect to chemical wastes is virtual elimination of discharges of persistent toxic substances into the environment. In addition to a bilateral action plan for pollution prevention in the Great Lakes and the St. Lawrence, the government is targeting the Fraser River and the

Atlantic coastal area for remedial action. For the former, monitoring, compliance and enforcement measures will be increased. Major elements of an Arctic Environmental Strategy deal with Arctic contaminants, vaste clean-up and management, and water quality.

Among the numerous needs identified in 1989 for Conservation and Protection of Environment Canada for toxic substances science, primarily in support of CEPA, are: transport mechanisms in multiple phases (water, active and inactive sediments, biota) in the Mackenzie River system and delta as well as fate and effects of toxic components; cumulative impacts of development activities in a water basin (e.g. Peace, Athabasca, Slave); development of models for use in assessing water basin fate and effects for multiple industries; ecotoxicology of petroleum hydrocarbons in northern temperate and Arctic waters; bioindicator tests and protocols for marine and freshwater receiving environments for pulp mills and metal mines; sampling and analytical protocols for soil, air, groundwater and surface water contamination from contaminated sites; development of criteria for assessing the quality of St. Lawrence River sediments; and development of integrated indicators of the state of the St. Lawrence River (management) to evaluate the impacts of various remedial measures.

WRB Role in Toxic Substances

Since the management of toxic chemicals must consider all relevant components of the environment (water, sediment, air, aquatic biota) to be effective, WRB has a role to play in initiatives to eliminate toxins. As toxins can be dissolved or attached to sediment particles, streamflow and sediment data are invaluable to studies on toxic chemicals, including sources of the chemicals, extent of contamination, impacts, and the assessment of remedial measures. For example, the data are used to calculate loadings, identify sources, travel times, etc. Furthermore, since the pathway to the water can be from point sources (outfalls) and non-point sources (runoff, atmospheric deposition), WRB attempts to design a comprehensive regional hydrology network capable of providing basic surface water information in major basins and zones, with specific purpose stations added where specific monitoring or operational needs are identified.

Present WRB activities of relevance to toxic substances and potential activities are outlined below.

Present Activities

- Streamflow data are used to calculate mass loadings of toxic substances entering the Great Lakes, the loadings information being required under the Great Lakes Water Quality Agreement.

- WRB provides equipment, expertise, and data that are instrumental in the research of the Centre Saint-Laurent.

Potential Activities

- Expansion of the hydrometric and sediment monitoring network for additional emphasis on monitoring of toxic substances. Industrial development, for example the oil sands and pulp mills in Alberta, will require such emphasis, in this case for the Peace and Athabasca River systems. This area is of concern because the fate of much of the toxins could be the Peace-Athabasca Delta area, which is a national park and wildlife-rich environment, and the Mackenzie River system downstream. This represents a regional ecosystem approach to environmental monitoring for sustainable development.

- Increased cooperation with water quality agencies to monitor discharge and sediment to control contamination. Efforts could be placed on determining the toxic substances transported by sediment processes and by the water mass. Included could be determination of fate, source, and transfer of sediment particles with the attached toxic substances. Specialized sampling equipment, monitoring procedure improvements, modelling of flow, regime, and sediment discharge would be required.

- Expand collection and analysis of sediment samples to include the application to water quality activities in the area of toxins carried by suspended and bottom sediments, and in solute.

- Increased efforts on toxic monitoring on major interprovincial streams to determine the effects and fates of agricultural contaminants.

- Model contaminant movement in groundwater systems to surface water. Point and diffuse contamination of toxins on land can result in substances entering the surface water either by overland flow or by migration through the groundwater system. The ability to model contaminant movement in groundwater systems to receiving surface water is of importance for the wise management of ecosystems.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: URBAN HYDROLOGY

Significance

As residential, commercial, and industrial development takes place across Canada, urbanization has major impacts on the environment, including the hydrology of rivers and streams. In 1941, a little more than 50 percent of Canada's population lived in towns and cities. By 1984, the figure was up to 76 percent. Effects of urbanization on water courses encompass both quantity and quality aspects, and include an increase in the amount of runoff, a decrease in the time-to-peak, higher peak flow, higher erosion rate, more flooding, degraded water quality, loss of wetlands, and change in species composition of the aquatic ecosystem. In addition, the pollution of urban waterways is so bad in some centres that some rivers are unfit for recreational use (ie: Toronto's Don River); storm drainage causes many beaches throughout Canada to be closed for bathing for periods during the summer. This urban pollution is also cause for concern for drinking water supplies. Thus, the effects of urban development on water can be felt across Canada.

With planning, these effects can be reduced. Catchment retention basins, bank stabilization, separation of sanitary and storm severs and their respective treatment, flood damage prevention, land use planning, conservation, and street-cleaning practices are among the tools that can be used to mitigate the effects of urbanization on the environment of local ecosystems.

Federal Involvement

Although municipal water and sever systems generally are a provincial/municipal responsibility, one of 25 specific policy statements of the Federal Water Policy (1987) is on the provision of municipal water and sever infrastructure. Between 1960 and 1980, the federal government provided loans and grants for the construction of main sever trunks, sevage treatment plants, and water supply systems. While the program terminated in 1980 due to fiscal restraint, the federal government plays a role in encouraging realistic pricing of such services. Such policies would not only raise the funds needed to build and maintain costly water supply and sever systems, but also foster water-use efficiency. Environment Canada, and more specifically the Water Planning and Management Branch of the Inland Waters Directorate, has done extensive research on municipal water prices in Canada, benefits and costs of water metering for municipalities, vastewater treatment, etc. The National Water Research Institute also does some research in urban hydrology.

Under the Green Plan (1990), the Government is committed to improve emergency preparedness within urban centres against flooding. "Modern, automatic local area environmental weather observation networks and detection systems will be set up in priority areas to monitor natural and man-made environmental disasters. For example, automated water-level monitoring equipment will be installed in streams above flood-prone, major urban centres by the end of 1994. Flood

forecasting agreements with other parties will also be established."

WRB Role in Urban Hydrology

Not only are WRB's data important to understand the hydrology of urban areas, but they are used for: the design and construction of catchment retention basins and bridges; the assessment of flood plains and the development of flood damage reduction plans; flow forecasting; determining erosion rates; and flood control assessment of point and non-point sources of pollution, as examples. Private industry, municipalities, and provincial agencies use the data.

Two examples of past application of data are provided. First, in 1982 the Essex Region Conservation Authority in Ontario requested WRB to construct and operate a station on the Little River at Windsor prior to construction of a new housing subdivision. The conservation authority was concerned about the impacts on flow patterns and water quality. Second, at Guelph, a gauge was operated between 1967 and 1984 to determine the effect of development of an industrial park and commercial use of a rural setting in the northwestern part of the city. Studies indicated significant impacts on the hydrology of the small creek flowing through the area.

Present WRB activities of relevance to urban hydrology and potential activities are outlined below.

Present Activities

- There are hydrometric and sediment monitoring stations located across Canada in urban centres and in rural areas above urban centres.

- WRB has a role under the Green Plan to establish water level equipment above major urban centres for flood forecasting purposes. These will be placed in conjunction with a weather network.

Potential Activities

- Consider the implications of urban development on the present locations of gauging stations. As development takes place in rural areas, existing stations may not be ideally located for the planning of urban development or to monitor the impacts of the development. Stations may have to be relocated or new stations constructed.

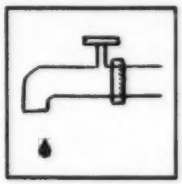
- Increased role for the measurement of water quantity and sediment in urban areas, since urbanization is expected to continue in Canada, so that the impacts of development on the environment are minimized.

- Perform interpretative studies on small rural and urban basins so as to better apprehend the hydrology of such sites vis-a-vis alterations in patterns of sediment processes, discharge, and pollutant loadings.

- Monitor, analyze, and interpret runoff from urban areas in partnership with other federal/provincial agencies, with regards to the transport of pollutants/toxins in storm runoff. Results of such an effort would have a positive effect on the regional ecosystem in the urban environment.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: WATER SUPPLY

Significance



Canada has an abundance of water, but its distribution and quality causes supply problems. While Canada has seven percent of the world's land mass and nine percent of the world's renevable water resources, 60 percent of the freshwater drains northvard while 90 percent of the Canadian population lives within 300 kilometres of the southern border. This inequality of distribution results in water-short regions, the scarceness being exacerbated during drought conditions. Areas that are vulnerable include the interiors of British Columbia and the southern Prairies, vhere water is essential for agriculture, and in the high Arctic. Water withdravals from the North Saskatchevan, South Saskatchevan, Milk, and Red-Assiniboine River basins of the southern Prairies, nov approach their reliable supply limits (supplies available 90 percent of the time). Furthermore, vhile the Great Lakes form the world's largest freshvater lake system, some off-lake areas of southern Ontario such as Kitchener-Waterloo experience periodic water shortage. Vhere water is readily available, it may be polluted, and usable only at relatively high cost of treatment, compounding the problem.

Federal Involvement

While water supply is generally a provincial/municipal responsibility, the federal government provides guidance. Where flovs cross international or interprovincial boundaries the federal government is mandated to monitor flovs and uses, so as to ensure treaties and agreements are being followed. The federal government encourages demand management instead of structural methods, vhich involve dams and reservoirs and their resulting environmental impacts. Demand management can be achieved through vater conservation, vater pricing, and vater use technology, as examples.

Under the Green Plan (1990), the government vill significantly accelerate the provision of vater and sever systems to Indian reserves in order to address health and safety problems. It will also sponsor a national conference in cooperation vith the provinces, communities and the private sector to promote viser vater use through improved demand management, realistic pricing, and the development and application of vater conservation technologies.

VRB Role in Vater Supply

Since an inventory of vater quantity and assessment of the reliability of this available vater are necessary for vater supply, VRB has a role to play in this field. The inventory is necessary for efficient and fair allocation of vater between users (ie: under transboundary agreements). It is also used in the design and construction of vater supply systems for irrigation, municipal vater supply, and for effluent dilution. The operation of a sound hydrometric netvork

provides the data necessary to assess the reliability of a regional water supply. The more the network is geared for water supply studies, the more precisely the variations in supply can be evaluated for the management of the resource. The sediment network is also used in the design of filters and intakes of water supply systems. Real-time data are useful during drought conditions.

Due to the immense area of Canada and the low number of discharge monitoring sites, significant gaps in regional coverage exist.

Present WRB activities of relevance to water supply programs and potential activities are outlined below.

Present Activities

- About 60 percent of WRB's 2700 hydrometric stations have as one of their uses the role of inventory of available water supply. About seven percent, or an estimated 190 hydrometric stations are used directly for water supply and sanitation purposes.

- Network planning and evaluation activities ensure that networks are as efficient and complete as possible given the available funds.

- Regional transfer methodologies and analytical approaches to determine the reliability of water supply are developed and made available to the hydrologic community by WRB.

Potential Activities

- Perform network evaluation and planning activities to identify the ability of the network to assess regional water supplies.

- Continue to develop analytical software to facilitate the interpretation of data for water supply purposes.

- Continue to develop methodologies to effectively transfer hydrometric and sediment data to ungauged basins or to basins with relatively short periods of record. These methodologies would allow the assessment of water supplies in a regional context.

- Install and operate additional gauging and sediment stations to fill in known regional gaps in the hydrometric and sediment networks. This would be a result of a network evaluation and planning exercise.

WATER RESOURCES BRANCH ISSUE PAPERS
ISSUE: WETLANDS

Significance

Wetlands are rich, aquatic ecosystems that are threatened by competing land uses. The functions of wetlands include groundwater recharge and discharge, reduced flooding through water storage, shoreline stability, sediment trapping, nutrient retention and removal (pollution filtering), food chain support, habitat for fisheries and wildlife, recreation, and sustainable peat production. Wetlands support one-third of the wildlife species identified as endangered, threatened, or vulnerable in Canada. Furthermore, wetland ecosystems generate between $5 and $10 billion annually in economic benefits to Canadians. As the various functions indicate, and as an interface between land and water ecosystems, wetlands are of high relevance to water resources management.

While Canada has almost one-quarter of the world's wetlands, covering 14 percent of Canada, it is estimated that losses in Canada amount to over 13 percent of our base. Across the country we have lost: 80 percent of Pacific estuary marshes; 75 percent of potholes in the central Prairies; 68 percent of wetlands in southern Ontario; 65 percent of Atlantic coastal salt marshes; about 50 percent of the Great Lakes wetlands; and 80 to 90 percent of wetlands within or adjacent to major urban centres. This list does not even consider how the character and quality, such as the loss of species, of the remaining wetlands have been affected.

Several factors contribute to the loss of wetlands. The greatest single threat to wetlands historically has been drainage for agricultural purposes, accounting for 85 percent of total known losses. Other causes include urban growth, industrial expansion, recreation development, hydro-electric power development, lake-level management, and forest harvesting. In future, climate change may be an additional factor. Over a long period of time climate change would lead to a modified distribution of inland freshwater supplies, and an overall change in hydrologic dynamics. New wetlands would be created and present ones destroyed along with some species.

Wetlands of other countries are also of significance to Canada. Many of the bird species found in Canada migrate to the United States, Mexico, etc., and vice-versa, and depend on wetlands elsewhere for this purpose. Thus, wetlands are of international importance.

Federal Involvement

The Canadian Wildlife Service of Environment Canada is the lead federal agency for wetlands.

Wetlands preservation is one of 25 specific policy statements in the Federal Water Policy (1987). One result is a Federal Policy on Wetland Conservation and

implementation plan, which was finalized in 1990. Environment Canada also continues to review environmental impact statements to ensure minimal impact of federal programs and activities on wetlands. Environment Canada manages 45 national wildlife areas and administers 99 migratory bird sanctuaries. The Prairie Farm Rehabilitation Administration (PFRA) is also involved in the area.

For international matters, the ongoing North American Waterfowl Management Plan (NAWMP) is a $1.5 billion Canada/US agreement (1990), which includes federal, provincial, state governments and nongovernmental organizations, for waterfowl habitat restoration and protection over 15 years. Another commitment is the environmental agreement with Mexico signed in 1990, which includes consideration for migratory species and sites. Another example is the designation of Canadian sites for an inventory of internationally significant wetlands of the International Union for Conservation of Nature and Natural Resources (RAMSAR).

Under the Green Plan, in 1991, the government will adopt the Federal Policy on Wetland Conservation. Elements of the Policy will include a system of secured wetlands of national importance; protection of wetlands on federal lands such as national parks, national wildlife areas and National Capital Commission lands; and wetland conservation as a fundamental goal of all federal land-use decisions. Wetlands will also benefit from the Wildlife Policy for Canada and the Canadian Wildlife Act.

WRB Role in Wetlands

The water quantity and sediment monitoring of WRB are relevant to the planning and management of wetlands sites. For wetlands projects, an integral part of establishing project feasibility is the determination of yield from the drainage basin, which requires flow statistics. In terms of project design, water control structures such as dams, dykes, weirs, and culverts may be used to manage the wetlands. Hence, hydrometric data, modelling, and regional transfer methodologies are needed to determine potential flood maximums. Continuous hydrometric monitoring can be used to determine average, low, and high flow hydrographs and are important to detect trends or changes in the flow regime of the wetlands. An increase or decrease can mean the creation or demise of a wetland, with consequences on flora and fauna of the ecosystem and the breeding habits of the creatures inhabiting the area, not to mention the ability of the ecosystem to support its various indigenous species. Sediment data help indicate the overall health of the ecosystem, help identify sources of contaminants, and processes involved in pollutant trapping.

Next to provincial Water Resources Branches, Ducks Unlimited is the largest user of WRB's data for the conservation and management of wetlands, particularly in the Prairies.

Present WRB activities of relevance to wetlands and potential activities are outlined below.

Present Activities

- About 13 percent, or an estimated 354 hydrometric stations are used for fisheries management.

- Data for about 50 to 100 gauging station sites are supplied regularly to Ducks Unlimited, a major cooperator in NAWMP, for studies and water management purposes.

- For Alberta, an estimate is that 50 to 80 hydrometric and one or two sediment stations are used for wetlands.

- WRB data are used to study the potential impacts of climate change on wetland hydrology, an example being the study by the National Hydrology Research Institute of the Inland Waters Directorate, McMaster University, and Ducks Unlimited.

Potential Activities

- Work with other agencies in the establishment of a national inventory of secured wetlands. The stations would provide invaluable information for the definition of the hydrologic regimes of the wetlands. WRB expertise could assist in monitoring and modelling for the maintenance and management of each national wetland site. Such an exercise could be established through the federal-provincial/territorial water quantity agreements.

- Continue to develop analytical approaches, environmental modelling, frequency analysis, regional analysis, etc., to assist users in the management of wetlands. In the past, many data users have identified an increased need for data interpretation such as frequency analysis and have suggested that the Water Resources Branch provide this service.

- Network evaluation and planning activities could consider future needs and implications of wetlands, particularly for smaller basins (less than 100 km^2), a need identified by managers of wetlands.

WATER RESOURCES BRANCH ISSUE PAPERS
CONCLUDING REMARKS

It is apparent from the issue papers that the programs of the Water Resources Branch serve wide-ranging purposes and are valuable for the economic and sustainable development of Canada. Our work is indispensable in determining the amount, source, and fate of contaminants; in assessing the amount of water available for human use; in studying the impacts of development on the environment, the supply of water available for agricultural production, or energy production; etc. Monitoring, modelling, and regionalization can serve several functions concurrently, reflecting the inherent interdependent nature of the issues themselves. Integration of the water quantity and sediment networks with other environmental monitoring groups is necessary to face the complex issues presented in this document.

We should be cognizant of how our analytical methods, data, and information contribute to the resolution of environmental issues on an ongoing basis. The process that evolved for the preparation of this report could be used to continue emphasis of the need for data integration and development of interdisciplinary expertise. We should periodically examine, say every three years, the extent to which we are contributing to the resolution of environmental issues and how this could be improved. This examination should draw on regional perspectives and expertise. Staff throughout the Branch should play a role in how we respond to this work. WRB Headquarters should be responsible for overall coordination and production of future versions of the Issue Papers. Finally, the Chiefs of WRB are responsible to ensure that the issue papers are considered in Branch planning.

WATER RESOURCES BRANCH ISSUE PAPERS
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The Water Resources Branch is the national agency responsible for the collection, interpretation, and dissemination of standardized surface water quantity data and information in Canada. Streamflows, water levels and sediment concentrations are measured across the country and interpreted as required. The data and information are made available in a variety of printed and computer compatible formats, including historical records, current year, and real-time. The national data base, HYDAT, is the primary source of surface water quantity information for water resource and environmental management in Canada. Each year HYDAT and related products are distributed to a wide array of users: federal and provincial government agencies, utilities, environmental organizations, consultancies, and the general public.

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La Direction des ressources en eau s'avère l'organisme national chargé de la collecte, de l'interprétation et de la diffusion de données et d'informations normalisées portant sur la quantité des eaux de surface au Canada. Les débits, les niveaux d'eau et les concentrations des sédiments sont relevés à la grandeur du pays, et les données et informations en découlant, dont des enregistrements historiques, des données pour l'année en cours et d'autres en temps réel, sont mises à la disposition des utilisateurs sous diverses présentations imprimées ou lisibles par ordinateur. La base nationale de données HYDAT constitue la principale source de renseignements au sujet de la quantité des eaux superficielles qui servent à la gestion de l'environnement et des ressources hydriques au Canada. Chaque année, les produits de HYDAT et les produits connexes sont distribués à une diversité d'utilisateurs : organismes fédéraux et provinciaux, services d'utilité publique, organisations vouées à la défense de l'environnement, experts-conseils, et grand public.

Pour de plus amples renseignements sur ce qui précède, veuillez communiquer avec la :

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